Substitute Specification for 10/619,130, filed 7/15/03 (marked-up version excluding claims)

~~Specification~~

~~001 Title of Invention:~~

Rearing Fly Larvae and Animals in Space for Waste Recycling and Food Supplying

This application is a continuation-in-part of application No. 10/178,344, filed on June 25, 2002.

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~~005 References Cited~~

~~U.S. PATENT DOCUMENTS Patent Number: 5,618,574 4/1997 Bunch 426/641~~

~~Only one related US Patent titled "Fish Food" was found in searching of US Patent from Jan.1974 to Nov.2001.~~

~~This patent applies dried fly larvae as fish food to improve the growth, feeding efficiency or coloration of fish.~~

~~Other Publications:~~

~~(1) Calvert c.c,et al, Poult.Sci,1970,49:588—589~~

~~—"Housefly larvae biodegradation of hen excreta to useful products."~~

~~(2) Miller,B.F., et al, Br.poult,Sic. 1974, 15:231—234~~

~~—"Digestion of poultry manure by Musca demestica."~~

~~(3) Teotia J.S,et al ,Br..Poult.Sci.1974,15:177—182~~

~~—"Nutritive content of fly pupae and mature residue."~~

~~(4) Pickens L.G., J. Med Entomd,1983,20(5):572—573~~

~~—"A new larval diet for Musca domestica"~~

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~~(6) Newton G.L.et al, J.Anim.Sci.1977,44: 395—400~~

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~~—"New diets for production of house flies and stable flies (Diptera:Muscidae) in the laboratory.~~

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~~"A Two-Step Method for Permeabilization of Drosophila Eggs."~~

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~~"Contributions of cooling and warming rate and developmental stage to the survival of Drosophila embryos cooled to -205°C."~~

~~(16) Wang Darui et al, Entomological Knowledge 1991 (4): 247-249~~

~~—"Analysis and utilizing of the Nutritional Contains of Housefly Larvae."~~

~~(17) Zhang Zhe sheng, et al, Science and Technology of Food Industry 1997 (6): 67-69~~

~~"Exploration House Fly Larvae as a Potential Food Protein Resource for Human."~~

~~(18) Li Guanghong, et al, Entomological Knowledge, 1997 34 (6): 347-349~~

~~"Nutritional evaluation of extracted Housefly Protein."~~

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~~"Growth and Survival of House Flies (Diptera: Muscidae) in Response to Selected Physical and Chemical Properties of Poultry Manure."~~

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~~"Exploitation of Housefly Larvae." Animal Research Institute, China Science Academy.~~

~~(21) Ren Guodong, et al, Entomological Knowledge, 2002 39(2): 103-106~~

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~~"Raising of Economic Insects and Its Exploitation."~~

~~006—Statement regarding federally sponsored research or development~~

~~Not Applicable~~

~~007—Incorporation-by-reference of material submitted on a compact disc~~

~~Not applicable~~

~~008~~—Background of the Invention

(1) Field of the Invention:

A method of waste recycling for food regeneration in the space.

(2) Background Art:

~~The~~ Sscientists in many countries~~, like~~ such as China, the USSR, the ~~USA~~United States, Mexico, Eastern Europe, Israel, Australia a Central and South America have studied ~~for~~ rearing maggots in manure ~~digestion,~~ to convert residual protein and other nutrients in animal manures to high quality maggot biomass for use as animal feedstuff. ~~(reference 1~13)~~.

In US Patent 5,618,574, Bunch discloses ~~to apply~~using dried fly larvae as fish food to improve the growth, feeding efficiency ~~or~~ and coloration of fish.~~,~~ ~~There are no any other discloses about using maggot to recycle human wastes and other wastes the space,~~

~~the maggot can be the animal's feedstuff, and the animals will be human's food in the space so far.~~

~~009~~ Brief Summary of the Invention

________In this invention we propose rearing one type of ~~the~~ maggot - housefly larvae (HFL)_as a space food source in addition to ~~besides~~ crop plants for waste recycling and food production in long term mission.

~~HFL~~Housefly larvae have great vitality and seldom get disease. They can be easily reared ~~with~~ in a small volume of containers where ~~HFL~~ housefly larvae and feedstuff could closely touch in microgravity under controlled constant temperature and humidity condition without much care. The feedstuff ~~are~~is ~~composed~~ made by mixing ~~of~~ ~~the~~ human/animal wastes (~~faces~~feces, urine; animal dejecta and leftover bits) and cast-off crops (such as wheat bran~~,~~ and bean dregs). The crops ~~is~~ may also be cultivated as ~~the~~ space food by NASA.

Thus the feedstuff nutrition from both human/animals wastes and crop waste can be all recycled to achieve the goal of efficiently producing nourishing ~~HFL~~housefly larvae. The ~~HFL~~ housefly larvae will be the food source for feeding animals.

The water and nutrition left in the residues remaining after rearing ~~HFL~~ housefly larvae can be recycled and used to fertilize~~d~~ ~~the~~ crop plants ~~again~~. ~~Besides, c~~Current self-supported space foods -- the crop plants~~,~~ such as wheat, potato, and beans -- mainly offer ~~most~~ calories and the plant proteins ~~necessary for~~needed by the human body. They can-not offer ~~some~~ other ~~adequate~~ nutrients such as animal protein, fatty acids, amino acids and so on. ~~HFL~~ The housefly larvae body consists of rich protein, 18 kinds of amino acids (~~thereinto 10 kinds~~10 kinds are necessary ~~to~~ for the human body), fatty acids and many kinds of vitamins, minerals, and electrolytes. Live housefly larvae and housefly larvae power~~The alive HFL and the powder of HFL~~ will be the ideal feedstuff for animals, such as ~~the~~ poultry, aquatics animals, amphibians, and livestock. These animal bodies combined with their eggs will ~~be~~ provide a varied ideal food – they are all meat diets for humans in ~~the~~ space. Fly eggs have very strong reproduction and growth ~~ability~~abilities.

Their reproduction and growth cycles are very short. They usually ~~get~~ mature in 4 days after being hatched, and their weight increase by 250~300 times. ~~The f~~Frozen maggot eggs have a long life and keep ~~with~~ their reproduction ability. For 5 crew in a ~~10~~ ten years mission, around 25 kg of fly eggs could be brought from earth at the beginning to provide a ~~for~~ food source without need for subsequent deliveries~~y again~~. Rearing maggots and animals combined with crop plants in ~~the~~ space would be a regenerative integrated system with closed loops of food, water, and air recovery from most wastes. The operations ~~of~~ involved in rearing maggots ~~are all under the~~meet restrictions ~~of~~ related to ~~minimum~~ volume, mass, energy and labor. It is an efficient, reliable and effective bioregenerative system ~~in~~ for long term missions.

~~**010 Brief Description of the several views of the drawing(s):**~~

~~**Not applicable.**~~

~~011 Sequence Listing:~~

~~Not applicable.~~

~~012~~—Detaiiled Description of the Invention

~~The current problem and way of solving the problem:~~

________~~Up~~ Tto date, all crewed space missions ~~were~~ have been short-term and in low earth orbit. They have relied on food ~~resupply~~ replenishment from earth. ~~The w~~Wastes ~~have to~~must be discarded or stored until~~after returning~~ the crew return to earth. But for future long-term missions and permanent planetary bases ~~on~~ such as those on the moon and Mars, it will not be possible to supply the crew from earth.~~the earth supplying mode will become Impossible~~. The recovery and recycling of nutrients from wastes to support food production ~~have to be done~~must be performed –in space, however, current technology cannot support this goal. ~~The~~ For example, NASA's ~~crop~~ crop-plant-based bioregenerative systems ~~provide~~ satisfy only a fraction of the total waste recycling (mainly CO_2 and gray water) and food requirements~~,~~. These systems ~~it~~ also requires high levels of light energy for maximum photosynthesis, large growing areas, and long growing periods. So current NASA~~'s~~ Advanced Life Support technology cannot provide the life support functions needed for long term human exploration of space in a cost-effective manner.

________Here we propose rearing one type of ~~the~~ maggot -- housefly larvae -- as a space food source to use in addition to ~~besides~~ crop plants for waste recycling and food production ~~in~~ on long term missions. As we know, ~~the~~ maggots readily feed on fresh manure~~, to~~ and convert residual protein and other nutrients in-to biomass, which is a high quality animal feedstuff with rich protein and other nutrients. The fly eggs can be ~~offered~~ provided with minimum ~~capacity~~ effort ~~in~~ on long term missions by freezing them in liquid nitrogen, so they ~~and~~ can be hatched and reared by warming them at any time. _Maggots ~~is~~ are fly larvae (FL), the scientific name of the housefly (HF) is Musca Domestica. We select Housefly Larvae (HFL) as a first candidate in our invention, ~~this is~~ because, HFL have strong reproduction ability, short life cycle, seldom get diseases, and are easily reared in high densit~~y~~ies with~~,~~ high efficiency and without much care. It is well known ~~by a great deal~~from many studies~~,~~ that HFL have the ability to flourish in virtually any animal manure (and certainly human manure too). They can convert these

wastes to high quality nourishing animal feedstuff without poison.~~,~~ The equipment and ~~operation~~ techniques needed to raise them~~for them~~ are simple. Also, feeding, processing, and storage of HFL, and the ~~using~~ use of HFL as feedstuff for ~~varied~~ various animals are all ~~the~~ mature technique on the ground. It may therefore be easier to transfer these techniques to space usage with less time and investment.

We do not select HF pupae as our first candidate even ~~if~~ though pupae contain rich nutrition ~~too~~ and ~~with the preferable stage f~~ are easy to~~or easy~~ harvest. The reason is that there is a loss of biomass in pupal development. Pupae are about half weight of ~~the~~ mature maggots and ~~more~~ the larger amount of chitinous exoskeleton ~~of~~ in the adult may reduce nutrient availability.

~~HF~~ Housefly larvae ~~has~~ have a fabulous reproduction speed. A couple of ~~HF~~ housefly larvae can produce around 1000 eggs during ~~its~~ their reproduction period (12-15 days). Theoretically, 1000 eggs can reproduce 200 billion adult HFL within four months. 200 billion HFL contain more than 600 tons of pure protein. The egg usually takes 4 days to become mature HFL and 10 days to fly. ~~It~~ They haves a short and speedy reproduction period ~~with~~ and a high output. The weight of one HF egg is around 0.08mg (one gram of HF eggs contains 12000-14000 eggs)~~[20]~~, the weight of one adult maggot will be 20~30 mg, which is 250~350 times larger after being reared for 4 days. ~~It~~ To date, housefly larvae are~~is~~ second~~-for~~-to-none ~~to~~ in ~~produce~~ producing animal protein~~-so far~~. Moreover, rearing HFL in the darkness ~~and~~ in an aeration room with temperatures of 25-28℃ and comparative humidity 60-80 %, ~~can~~ allows them to reproduce continuously generation after~~by~~ generation. HFL are light avoiding insects, so they should be reared in dark containers instead of in the light as for plants photosynthesis.

Nutritional content of ~~HFL~~ Housefly Larvae

The data ~~indicating~~ below is from four national academic institutes in China.~~[16],[17], [18],[22]~~ (See, Wang Darui et al, Entomological Knowledge 1991 (4): 247-249 "Analysis and utilizing of the Nutritional Contains of Housefly Larvae."; Zhang Zhe sheng, et al, Science and Technology of Food Industry 1997 (6): 67-69 "Exploration House Fly Larvae as a Potential Food Protein Resource for Human."; Li Guanghong, et al, Entomological Knowledge, 1997 34 (6): 347-349; "Nutritional evaluation of extracted Housefly Protein."; and Wei Yongping et al, China Agriculture Press, Beijing, August 2001, "Raising of Economic Insects and Its Exploitation.")

The Analysis ~~Results of HFL's~~ Housefly Larvae Nutrition

~~The~~ Housefly larvae ~~HFL~~ powder is dried from fresh HFL. Its weight is ~~around~~ about 1/3 that of fresh HFL. HFL powder contains 54-63% ~~of~~ protein which is more than that of fishmeal powder. ~~The~~ Ffat accounts for 11-17% of HFL powder, ~~with~~ similar to ~~composing of~~ plant oil or fish liver oil. Amino acids are well combined with 9 kinds of essential amino acids for humans. The total amount of essential amino acids crucial to human ~~lives~~ life is 2.3 times that of fishmeal, ~~the~~ storage of lysine, methionine and phenylalanine ~~are~~ is 2.6, 2.7, and 2.9 times that of fishmeal, respectively. Two of the essential amino acids, lysine and tryptophan, are poorly represented in most plant proteins. The essential amino acids account for 43~47%(E%), which is more than the referenced standard (40%) issued by FAO/WHO. Essential–

amino acids/ non-essential (E/N) is 0.70-0.89, which is much more than the referenced standard (60%) issued by FAO/WHO~~[20]~~.

HFL powder contains rich amounts of K, Na, Ca, Mg, P and ~~a lot~~ many ~~of~~ trace elements necessary for humans such as Zn, Fe, Mn, Cu, B, P, Gr, Co, Al, Si, etc, ~~,~~ and also contains sufficient vitamin A, D and B. The content of vitamin D is similar to that of ~~with~~ fish-liver. ~~It especially~~ Notably, HFL powder contains rich amounts of vitamins ~~-~~ B_1 and B_{12} that are insufficient in ~~the~~ crops. B_1 and B_2 levels are, respectively, 15 and 1800 times ~~that~~ those of milk ~~[21]~~.

Table 1 Nutritional contents of HFL powder, HFL protein powder and fishmeal (%)

	HFL powder			HFL protein powder	Fishmeal
~~Data From Ref.~~ Content	~~[22]~~	~~[18]~~	~~[17]~~	~~[18]~~	~~[16]~~
Protein	60.88	54.47	62.70	73.03	38.6-61.6
Carbohydrate		12.04		0	2.80
Fat	17.1	11.60	11.20	23.10	1.2
Gross Fiber		5.70		0	19.41
Ash Content	9.2	11.43	10.42	1.83	20
Moisture Content		5.80	5.10	3.34	11.40-13.50
Chitin			3.97		

HFL protein powder is enriched from HFL powder processed ~~with method of~~ using acid deposition techniques.

Table 2 HFL Fatty acid

Contains of Fatty acid (g/100g)			
~~Data From Ref. (17)~~			
Myristic acid	2.2	Linoleic acid	32.5
Palmitic acid	19.7	Linolenic acid	3.3
Stearic acid	2.3	Saturated fatty acid	27.4
Palmitoleic acid	12.7	Unsaturated fatty acid	68.2
Oleic acid	18.2	Essential fatty acid	36.0

Table 2 shows how~~he above table indicate~~ non-saturated fatty acids ~~of~~ in HFL powder account for 68.2% of total amount of fatty acids. ~~Thereinto~~ Essential fatty acids account for 36% (Mainly Linoleic acid). Plant oil contains much more Linoleic and Linolenic acid with richer nutrition than those of animals. HFL belong to animality, but ~~it~~ contains much more essential fatty acid than peanut oil ~~and~~ or vegetable seed oil.

Table 3 Amino Acids of HFL powder, HFL Protein powder and fishmeal (%)

(*Amino Acids essential for human)

~~Data From Ref. No.~~	~~[22]~~	~~[18]~~	~~[16]~~	~~[17]~~	~~[18]~~	~~[16]~~
Amino Acid		HFL		HFL protein		Fishmeal
Aspartic acid		5.4	6.18	9.58	7.60	2.85
Threonine*	2.30	2.39	2.03	4.59	3.17	1.15
Serine		1.83	1.58	4.03	2.57	1.34
Glutamic acid		8.91	8.20	15.06	10.67	5.34
Glycine		2.36	3.84	4.55	2.67	3.27
Alanine		3.64	2.49	6.10	3.21	2.28
Cystine*	0.43	0.31	0.67	1.17	0.50	0.23
Valine*	2.76	2.87	3.23	5.05	3.71	1.58
Methionine*	1.49	1.26	1.25	2.42	2.27	0.46
Isoleucine*	2.34	3.10	2.54	4.21	3.98	1.09
Leucine*	3.57	3.85	4.05	6.92	5.68	2.07
Tyrosine	4.30	3.24	3.22	6.15	5.27	1.37
Phenylalanine*	4.32	3.08	3.51	5.74	4.87	1.19
Lysine*	4.30	4.45	4.30	9.32	4.97	1.64
Arginine		2.18	3.70	5.23	3.88	2.31
Histidine		1.27	1.96	2.91	1.59	0.70
Proline		2.19	4.16	4.08	2.34	2.79
Tryptophan*	0.78			1.10		

E	27.59	24.65	24.80	46.67	34.42	10.78
N	27.68	32.47		51.54	34.62	21.29
E+N		52.33	57.27	98.21	69.04	32.07
E%		47	43	48	49	34
E/N		0.89	0.76	0.90	0.99	0.50

E: Total amount of essential amino acid, N: Total amount of non-essential amino acid.

E%: Percentage of essential amino acid, E/N: Ratio of essential amino acid and non-essential amino acid.

Table 4 Analysis Result of Several Minerals and Trace Elements in HFL Powder

Minerals and elements (PPM)			
~~Data From Ref. [16]~~			
K	71.72	Zn	4.40
Na	20.00	Fe	2.33
Mg	26.97	Mn	1.98
Ca	34.12	Cu	0.29
P	62.35	B	0.19

Table 5 Analysis Result of Vitamin Content in HFLs

Contains of Vitamin (mg/100g)			
~~Data From Ref. [17]~~			
K	0.35	B1	12.85
A	1.17	B2	28.86
D	1.08	B6	7.83
E	0.45	B12	188.04

Storage of HF eggs and HFL food in space:

1. Cryopreservation of fly eggs in long duration missions.

Our invention ~~is to gain~~provides ~~nutrient~~ nutritional food for the crew of a spaceship by rearing HFL and feeding animals in space.

_______~~Here w~~We propose ~~the brief operation in space by the section of egg to HFL in normal rearing~~

~~operation.~~

~~That means~~ to only rear~~ing~~ HFL in-stead of ~~fly~~ flies in ~~the~~ space~~.~~, b~~B~~ecause ~~in space to~~ rearing ~~HF~~ flies in space ~~will~~ would take more room and labor than rearing larvae. ~~Therefore there~~

There is a need to bring adequate fly eggs from earth for food source storage in long term missions. _Fly eggs could become HFL after being hatched. _HFL ~~get~~ mature in 4 days and could become animal feedstuff by ~~living~~ producing HFL or HFL powder.

~~This concerns technology of~~ F~~f~~rozen HF eggs ~~storage~~ stored for ~~in~~ long term missions ~~to by keeping~~may maintain their strong reproduction and growth ~~ability~~abilities. ~~With~~In ~~10 m~~more than 10 ~~ore~~ years of research, it has been demonstrated that ~~currently~~ Drosophila (Fruit Fly) eggs ~~could~~ can be hatched successfully after ~~reserving~~ freezing them in~~under~~ liquid nitrogen. _Drosophila ~~egg~~ eggs frozen in this way can ~~could~~ grow to fly and ~~keep its~~ maintain their reproduction ~~ability~~abilities. Lynch of Cornell University reported~~,~~ that they can reach a 75~90% ~~high~~ hatch rate ~~[14]~~ and Mazur~~,~~ has demonstrated that the hatch rate can reach 70~80%~~[15]~~. Insect eggs can ~~be recovered by~~therefore be preserved by storing them in liquid nitrogen ~~with~~ for an unlimited ~~term~~ duration, as long as ~~keeping~~ the egg cases ~~in~~ are maintained at a proper permeability before being frozen and a controlled~~ing~~ warming rate is used.

~~Therefore w~~We ~~suppose~~ believe that houseflies~~HF~~ can reach high hatching rates ~~as well~~like ~~as~~ Drosophila, because they are all flies.

2. Amount of HF eggs for storage in long duration mission

We can bring ~~enough~~ sufficient frozen HFL eggs into space because ~~while~~ eggs are small in size, light-weight and easy to store~~age~~ ~~in~~by freezing~~e~~. ~~They~~ The eggs can maintain their reproduction and growth ~~ability~~ abilities ~~in~~ while frozen~~eeze~~ for several decades or hundreds of~~-~~ years, just as human semen can~~could~~ live that long ~~in~~when frozen~~eeze~~. According to our calculations, for every day, each astronaut needs 400g of fresh HFL, which is equivalent to 130g HFL powder. ~~It~~ Powder contains ~~around~~ about 80g of protein (see Table 1), which ~~that~~ meets the daily protein needs of an adult. There is a need ~~of~~ for ~~around~~ about 6 grams of eggs ~~for~~ to raise~~ing~~ 1.6 kg of HFL in 4 days and ~~around~~ about 0.5 kg eggs for one year. Thus, for 5 astronauts in a ~~10 years duration~~ mission of 10 years in duration, ~~it needs to bring around~~about 25 kg of eggs should be brought from earth. ~~It~~ This is an acceptable ~~loading weight~~payload to bring into space ~~in space for~~for several decades worth of food resource ~~in several decades~~s.

3. Storage of food and food sources in space

In this food bioregenerative system, as the food (HFL and the feeding animals) is ~~daily~~ produced daily in space locally, ~~the~~ food storage becomes simple. It is envisioned that these food sources ~~can~~will ~~be~~ usually be reproduced by themselves in ~~the~~ space too. There are two kinds of storage, one is for the storage of ~~those~~ animality foods (-animal meat and eggs) and maggot powder. This type of storage is ~~It is~~ the same as on ~~ground~~ earth for common frozen storage. Another ~~is~~ kind of storage involves food source storage~~for those food source storage~~, such as the storage of fly eggs, animal eggs, oosperm and placenta. ~~They~~ These items can be frozen in liquid nitrogen for cryopreservation ~~in long~~for long durations. The technology of frozen storage, and re-warming these items~~m in~~ while maintaining ~~keeping of~~ their strong reproduction and fast growth ~~ability~~ abilities has been basically solved on ~~ground~~earth. These food sources ~~have long life by~~can be preserved for a long time by storing them in liquid nitrogen. Theoretically, they can be stored ~~with~~ for an unlimited duration ~~term~~ and can recover from thawing. There is no need ~~of much~~for great care ~~about~~ with these food sources during ~~the~~ long-term ~~freeze~~freezing. They can be ~~taken~~ removed from storage and unfrozen easily at any time.

HFL rearing and waste recycling in space

The feedstuff for HFL in space is very simple, mainly using human and animal wastes (manure), inedible parts of space animal bodies and crops. HFL readily feed on fresh human waste as its feedstuff, ~~this is~~ because ~~the~~ human waste contains rich nutrition. Most nutrients from all of these wastes can be provided back to the crew by taking the food from animals which are fed by HFL.

The residues remaining after rearing HFL ~~is~~ are odorless and can be used by crop plants as high grade fertilizer. ~~[2][5][20]~~.

1. The formulation of feedstuff for HFL (weight percent of the feedstuff), is varied on different animals:

Fresh human waste (feces and urine) and ~~Fresh~~ fresh animal waste (manure and animal body residues): 85~90%.

Residues of space crops (wheat bran, bean dregs, and pieces of crop stalk/leaf): 10~15%.

2. Processing of the feedstuff before feeding:

Mixing of above composition in a closed container, humidity of the feedstuff in range of 70%$\pm$5% (adjusting by the volume of the urine), temperature in 25-30^{0}C, keeping the feedstuff as fresh as possible.

3~~,~~. Transplanting of the HF egg on the surface of the feedstuff:

The HFL eggs are ~~token~~ removed from their liquid nitrogen container in ~~ultra~~ ultra-low-temperature frozen storage, and then warmed for hatching. For a suitable density of feeding HFL, 1 kg feedstuff may be matched with 1.0~1.5 gram HFL eggs.

4~~,~~. The conditions for rearing:

~~There are a~~ S~~-~~serial numbers ~~of same~~ may be provided on the ~~-~~containers used for rearing HFL. The number depends on the output needs of the HFL . The containers are all closed for odor control. In the containers: the temperature is 28$\pm$2^{0}C, the humidity is 70 $\pm$5 %. ~~Installing a~~ Aeration pipe is installed in both the upper and middle layers for good aeration and oxygenation ~~-offering~~, and to keeping the aeration speed with 1 grade. The odor flowing in the aeration pipe will be filtrated by the deodorizer. ~~Stirring the~~ The feedstuff is stirred once a day ~~for~~ to avoiding ~~the over hot and short of oxygen~~ overheating and internal oxygen shortages ~~internally~~ after placing fly eggs in the feedstuff. _Before rearing, the feedstuff and containers should be placed in a microwave oven for bactericidal processing. The interior ~~Inside~~ of the containers ~~be~~ should be maintained ~~kept~~ in the dark with darkness ~~12:12~~.

5~~,~~. The structure of the containers and the rearing procedure:

Each container volume is 40X40X12 CM^3. It is much smaller than that on earth~~-~~. Bbecause in ~~status of~~ microgravity, HFL and feedstuff have to closely touch in order to keep feeding all the time. Usually, 1 kg of mature FHL can be produced within one rearing cycle of 3~3.5 days for each container. The container is divided by three layers with thickness of 8 cm and 2 cm and 2 cm respectively. The upper layer is 8 cm thick for HFL rearing only. It is full of feedstuff. The middle layer with a thickness of 2 cm contains wet wheat bran or bean dregs for decontaminating the viscera of the HFL after 3 days of rearing. The lower layer with a thickness of 2 cm contains wet wood bits or silver sand for making the mature HFL hungry, collecting and cleaning the mature HFL. There are two mesh screens between the three layers. The HFL skin can be cleaned while it goes through the tight screen opening.

The HFL can be driven to middle and lower layers by strong lighting on the surface of the layer and can stay in both of the layers for 3~4 hours respectively. They ~~, then~~ can then be collected in the lower layer~~,~~ after 3.5 days of rearing. Do not take 4 days as the collecting time, as this is ~~of consideration of the~~ considered to be the maximum biomass harvest ~~of the~~ for HFL to prevent any HFL from becoming pupa. After rearing HFL, all the

residue, which consists of ~~the~~ water and useful contents, can be recycled as fertilizer for space crop plants.

Rearing HF in space.

~~The~~ F~~f~~ly rearing and reproduction could be a standby ~~way~~ method for sudden use in ~~ease in~~ long term missions. Moreover, it is easier to rear HFL than HF in space, so a great deal of breeding space, labor and expense for rearing ~~fly~~ flies can be saved. In normal situations, there is no need to rear ~~HF~~ flies ~~in~~on long term missions because the problem of storage of HF eggs has been solved. But ~~in~~ as a contingency ~~of~~ upon losing ~~some~~ eggs, the crew ~~have~~ can~~to~~ rear ~~HF~~ houseflies to make up for the ~~for complement of~~ lost~~ing~~ eggs. Therefore the technology of rearing ~~HF~~ houseflies should be reserved. Rearing HF in space shall ~~be as~~ take into consideration the following points

1~~,~~. **Rearing quantity and density**:. The rearing density of HFL on the ground in large scale is 40000-60000/m3, but in space, where the crew only needs to rear a small number of flies for egg collection ~~only~~, ~~to rear~~ flies can be reared~~y~~ in ~~the~~ a cage with a size of 40X40X40 cm^3. It is a closed cage having ~~, the~~ four ~~side of~~ cage walls each of which is ~~are~~ all ~~with~~ mesh for aeration. For one fly, its minimum active range is 10 cm^3, so 3000 ~~couple~~ pairs of flies can be reared in one cage. In this cage, 13~15 gram eggs can be laid every day. (-600 eggs can be laid by one ~~couple~~ pair of flies within 10 days, one gram of eggs contain 12000-14000 eggs, so 3000 couple flies can lay 13~15 gram per day). ~~It is enough~~ This is sufficient for the food source needs of 9~10 crew every day. (-one crew need 1.5 gram fly eggs as the daily food source)

2~~,~~ **Feedstuff**:

The feedstuff of ovipositing HF is required to be better than that of HFL, because ~~HF~~ houseflies like~~s~~ to eat~~ing~~ HFL paste (smash live HFL into paste), and fortunately, the HFL paste could be easily produced self-sufficiently in space. ~~The~~ A formula ~~of~~ for the feedstuff for HF in space contains:70% of HFL paste and 30% of wheat bran or bean dregs.~~:~~

3~~,~~ **Approach ~~of~~ for rearing FL in space:**

~~Rearing~~ HFL ~~is the same as the above~~ may be reared as~~-~~mentioned above. Before HFL reach maturit~~y~~e, ~~usually~~ they usually take 4 days of rearing.

The HFL are all in the lower layer of the rearing container with wood bits for pupating, at a temperature within 24~32^{0}C, a humidity of 60~70%, kept in the dark ~~and~~ with an aeration speed of 0.5~1.0 grade. Choose the pupa whose weight is more than 18 mg as the seed. Pupa will have eclosion after 5-7 days, while HF can oviposit 3 days after eclosion and the ovipositing period is 30 days or so. As a rule, HF will be killed after 15 days of ovipositing and ~~stop getting eggs~~ egg gathering will be terminated to~~for~~ ~~assuring~~ assure ~~the~~ satisfactory egg quality.

The r~~R~~earing temperature in the HF rearing cage is 28~30^{0}C, the humidity is 60~70%. The feedstuff for rearing HFL is supplied ~~with~~ using a small feedstuff box in the cage, including an absorbed water sponge, feedstuff sponge and lured ovipositing sponge (-the sponge absorbs water and feedstuff to prevent the water and feedstuff from floating off under the microgravity). In addition to fresh human ~~faces~~ feces as ovipositing lured matter paste on, the feedstuff is the same to be applied on the lured ovipositing sponge, which can be put into 3 days after eclosion of pupa, at intervals of 12 hours. These three sponges should be alternated and the HF eggs could be collected once every morning and afternoon. The rearing cage needs to be sterilized with ultraviolet ray before rearing, HF pupa comes to eclosion after being disinfected by using potassium permanganate. Rearing HF ~~needs~~ requires lighting. Longer lighting times provide greater ~~, the longer time of lighting , more~~ benefits for FL growth and ovipositing.

Processing of HFL powder

1) Steps: Collecting Fresh HFL→Cleaning→Drying→Grinding→bactericidal procedure→Collecting powder→Package→Storage

2) Drying: Microwave under 80^{0}C

3) Drying within 6 hours after collecting HFL to prevent fresh HFL from becoming pupa.

4)

The HFL powder can be stored ~~in~~ by freeze~~e~~ing for long term preservation.

Application of HFL as feedstuff for animals:

Due to the rich protein and other nutrition that HFL contain, applying HFL as feedstuff ~~offers~~ provides good animal protein and other rich nutrients to poultry, livestock and aquatics to achieve large rate of reproduction and survive. This has been demonstrated by~~It was proved by~~ many countries in the

world.~~[1][2][3][4][5][6][7][10][12][19][20]~~. As the intake ratio of hens fed by feedstuffs is about 30%, a great deal of nutrition are left in the hen's manure. HFL can recycle the nutrition from manure. Researchers have conducted e~~E~~xperiments that demonstrate that when ~~points, the~~ HFL are~~were~~ reared ~~by~~ on the manure from three hens, -

~~It can meet~~ the nutritional demand of two hens ~~[22]~~ may be met. Thus, only one hen's feedstuff can sustain three hens. This is the best proven example for HFL fed by manure. The method can not only save feedstuffs, but also assure ~~of~~ good health.

Feeding Animals ~~by~~ on HFL in ~~the~~ space:

The proportionate nutrients of HFL powder are of free of pathogens and toxicity and have a~~with~~ quite mild taste. From its nutritive value and special health-keeping ~~function~~capabilities, HFL ~~it~~ should be an ideal food for humans in space. This is the most simple food chain ~~in~~ for recycling ~~of the~~ waste in space. But in fact, people's cultural barriers and eating habits make ~~themselves rather~~it rather difficult to accept insects as food~~,~~ (not to say HFL, the dirty insects with human waste as their food)., in ~~such an inclement~~the -environment of space. Therefore, in our design, the first key step we ~~have to~~must complete is to convert all ~~the~~ wastes from human, animals and space crop efficiently into HFL. The second step is to take HFL as animal feedstuff. These animals and their eggs are looked upon as human food. In this way, the HFL and animals will be the medium loops between the human food and wastes. Their function is to recycle wastes to be human food. Thus, a closed food chain, food to waste to food can be completed with HFL and feeding animals. The embarrassment of taking HFL as the human diet can be avoided. HFL as the animal food and animals as the human food can be easily ~~acceptable~~accepted. Researchers have successfully fed~~The animals of~~ poultry, aquatics, amphibians, and livestock ~~are successfully fed by~~ maggots both in farms and labs~~.[1]-[13]~~.

In this invention, we recommend the partridge, tilapia and America bullfrog as the first candidates for space testing animals, (the swine may be ~~the~~ a future candidate). The reason to choose the above-mentioned three kinds of animals as the space feeding animals is~~,~~ that they have common grounds as follows:

Their feedstuff all can be self-sufficient in the space. The ~~delighted~~ favored feedstuff of ~~all of them~~these animals is living HFL and HFL powder, and a~~other~~ ~~accessorial~~ supplemental feedstuff is inedible crops (wheat bran, bean dregs and so on~~),~~). During their puerile stage, these animals ~~puerile stage,~~ can ~~all~~ be fed with HFL power with added~~ing~~ inedible crops and they~~,~~ then can be fed ~~with~~ by adding living HFL after they grow up.

These animals are successfully fed on the earth by feeding maggot who convert the nutrients from animal waste. Researchers have demonstrated this in ~~These~~ feeding tests using ~~utilized~~ chicks~~[12]~~, pigs~~[6]~~, ~~C~~catfish and tilapia ~~[7][8]~~, frogs ~~[12]~~, and ~~the~~ partridges. ~~(We just done in June of 2003)~~

~~**They all had primary space hatching and feeding experiments, though these experiments are merely zoology experiments under microgravity, whose aim is not to feed them as food. However, they also**~~**Researchers have also demonstrated that these animals can be feed~~ing~~ ~~them~~ in the space~~ is feasible:~~**

~~I~~For example, in February,1999, 37 ~~little~~ partridges ~~have been~~were hatched ~~out~~ from 60 partridge eggs by the crew in Russian Peace ISS. Even though ~~in the~~there was a bad environment of strong ~~radiant of the space~~space radiation, ~~yet~~ 10 were alive. In an e~~E~~mbryology study of South African Frog performed on the~~in~~ US STS-47 Space Shuttle it was show~~s~~n that ~~the~~ eggs could be laid by ~~the~~ frogs in ~~the~~ space. Those eggs ~~were all~~ hatched into~~out to little~~ polliwogs. Experiments with fish and spawn ~~are~~ have also been performed by researchers successfully.~~made successfully as well.~~

Another significant advantage of feeding aquatic animals is that they originally live in the water which is similar to the microgravity environment of the space. Therefore, their zoology in the space, especially taking food and reproduction in water, will be the same as on the earth and not affected by microgravity. FHL can survive for over 24 to 48 hours on the water surface~~[20]~~. ~~S~~so it is convenient for the aquatic animals to eat active FHL in the water as on ~~the globe~~earth.

~~The w~~Water is a basic source for the survival of humans and animals in space. Fortunately, there is information indicating the apparent presence of ice in permanently shaded area at the south pole of the Moon. Also water is known to exist on the polar ice caps and below the surface of the Mars. Once these water resource can be exploited on these planets, it ~~is~~ will be easily to rear ~~varied~~ various aquatic animals ~~in~~ on a large scale by feeding them maggots~~ on these planets~~.

The eggs of these animals can be brought from earth and be stored in liquid nitrogen for long term cryopreservation, just the same as the fly eggs, and ~~then~~ can then be hatched after ~~re-warm~~thawing. ~~However~~Moreover, they can reproduce by themselves in ~~the~~ space.

These animals have small sized ~~body~~bodies, fast growth, ~~and short~~rapid ~~mature~~ maturity~~term~~, high rates of oviposition, can be densely reared, and are strong in anti-illness and adaptation. Their~~Its~~ meat is all high protein food with low fat and low ~~cholesterin~~cholesterol, easy for digesting with good taste. ~~As fo~~In the~~r~~ example

of partridge, its ovipositing term will be 35-45 days after hatching. The rate of oviposition is higher then 80%, weight rate of egg/body is 2.5~2.7 times higher than that of chicken. Partridges have a small appetite -- ~~Small capacity of diet,~~ the weight ~~rate~~ ratio of diet/egg is 3. Partridges like ~~Prefer~~ to eat maggots. The maggots ~~prefers~~ like to eat ~~the~~ partridge manure. In our 60 partridge feeding tests with HFL, the daily manure of two adult men and 60 partridges, with adding 10% manure weight of wheat bran as the feedstuff for rearing HFL from 2.5 gram of HF eggs, can harvest around 600 g fresh HFL every day. The partridge average weight increases 13% by feeding daily diet with living HFL (10 g HFL +25 g normal feedstuff) compared with a control group ~~with~~ having a normal diet (40g normal feedstuff) within a ~~27~~ 27-days feeding period. ~~Same~~ This is similar for~~as~~ the tilapia, ~~its~~ whose ~~mature~~ maturation term is very short and which~~,~~ can be used~~token as~~for food ~~after~~ 2-3 months after hatching ~~2~3 months,~~ and which can oviposit and hatch~~ing~~ by themselves ~~with~~ at a high rate while being fed in a closed water tank without much care.

~~(6)~~ The technologies for rearing these animals on ~~the ground~~ earth are mature and well known.

The safety of the HFL and HFL powder:

(1) The p~~P~~athogen-~~-~~free nature of ~~the~~ HFL and HFL powder:

HFL ~~has~~ have special immunity ~~ability~~ abilities for resisting bacteria. Their ~~body~~ bodies contain~~s~~ many kinds of active protein that ~~for resisting~~ resist bacteria ~~greatly. That is far greater~~ more strongly than penicillin ~~[22]~~.

The b~~B~~acteriological interactions associated with manure digestion by maggots are favorable. Maggots are competitors with bacteria for nutrients and often reduce bacterial numbers~~, to~~or eliminate them altogether. Maggots may consume and digest microorganisms~~,~~ and produce antibacterial and/or fungicidal compounds. Numerous studies using dried, rendered and fresh maggots as animal feed have revealed no health problems resulting from this practice. Culturing of self-collected soldier fly prepupae from a recent swine trail revealed no pathogens~~.~~ ~~[12]~~.

~~Reference [17] pointed,~~ Researchers have demonstrated that assays ~~on~~ of 100g HFL powder ~~from~~ using the ~~above~~ above-mentioned processing steps are free from~~:~~ colic bacillus and pathogens ~~are all free~~. T~~, t~~he total bacteria ~~number~~ count is lower than standard milk powder. ~~It~~ This shows that ~~this~~ HFL powder ~~as~~ is edible as human food ~~is edible~~.

To ~~assume of~~ rearing ~~FHL~~ HFL in space, the eggs are retrieved from cryopreservation; the feedstuff and rearing containers can be disinfected in advance; the processing of the HFL powder is performed ~~under~~ using bactericidal procedures. As a result, ~~So~~ the HFL and HFL powder can be assumed to be pathogen free.

(2) Without poison:

~~References[16][17][18][22]offer~~Researchers have produced data ~~for~~ analysing the ingredients of HFL powder and have demonstrated that ~~prove~~ HFL powder is a ~~rich~~ protein-rich food without any poisons.

Ideal fertilizer for space crop--the residues after rearing HFL:

In our experiments, the wastes (35% fresh human dejection+55% partridge manure and+10% wheat bran) were ~~Digested~~ digested by HFL ~~so fast~~quickly. The odor from the waste is almost ~~free~~ gone after one day of rearing. The residual waste is ~~Reduced~~ reduced 57% after 3 ~~days~~ days of rearing.

~~Miller etc.[2]~~Researchers have -reported~~,~~- that after HFL ~~digesting~~ digestion of ~~the~~ hen manure, ~~the~~ residues still contains 15% protein. This ~~It~~ can be used as ~~the~~ a ~~good~~ soil improv~~ing~~ement agent or fertilizer. ~~,~~ Further, 80% ~~organism material of~~of the hen manure is converted by HFL~~,~~ and loses about half of the moisture, dry matter and total weight at the same time, ~~but~~ only keeping its ~~the~~ ash ~~keeps~~the -same~~,~~.

Researchers have ~~Teotia etc.[3]~~ reported~~,~~ that after HFL digest~~ing of~~ the hen manure, the residue contains 17.62% protein, nitrogen is reduc~~t~~ed~~ion~~ from 7.5% to 2.6%, ~~the~~ and phosphorus is reduced~~tion~~ from 3.4% to 1.8%. ~~Sheppard reported [10][9],~~ Other researchers have reported that their manure management system (using black soldier fly) can reduces residual manure by 50%, including a 24% reduction in nitrogen concentration within this 50% residual manure, resulting in total nitrogen reduction of 62%. More recently, ~~he suggested~~researchers have suggested that a higher rate of nitrogen removal is possible, as is a significant reduction in phosphorus. It is evident that nitrogen and phosphorous removal ~~as~~ from wastes by their incorporation into maggot biomass will provide ~~be~~ a significant benefit in nutrient management.

~~The Moscow Biology Medical Research Institute reported~~Researchers have reported that~~,~~ the manure residues remaining after HFL ~~digesting~~digestion are~~, is~~ a kind of humic matter with no infective pathogens. Use of ~~it~~ these residues as fertilizer for tomato, cucumber, black mushrooms etc. ~~,~~ can ~~get~~ produce~~the~~ high rates of production and good quality~~[20]~~. ~~Morgan& Eby [5] reported,~~Researchers have reported that using HFL, one can convert 100 Kg of fresh hen manure or cow manure to 2~~ ~3Kg~~-3 kg of protein feedstuff and~~,~~ can ~~also~~ produce 50~60 kg of dry

and odorless soil improving agent. As maggots can reduce pathogens in human/animal waste, they may make it safer for organic vegetable production.~~[12]~~

~~The o~~Other functions of maggot powder:

Due to lack of protection ~~of~~ from the earth's atmosphere~~aerosphere~~ and magnetic field in space, there ~~are~~ are ~~obvious~~ harmsful effects on ~~on~~ the human body ~~by varied~~due to strong space radiation ~~while~~ when humans live~~ing~~ in ~~the~~ space. These effects include ~~, such as the~~a reduction ~~of~~in the number of ~~the~~ white blood cells and immune cells, ~~causing~~ cancer, damage to ~~and hurt of the~~ fertility~~, ability~~ etc. ~~To~~ The desire to resist ~~of~~ the harmful effects of ~~s from~~ space radiation has lead to ~~is the important~~ research programs at~~in~~ NASA and in many countries ~~in~~of the world, but to date no ~~there is no~~ effective way ~~yet~~to overcome these effects has been developed.

Tests ~~The tests~~ have proved that~~,~~ ~~taking~~ eating ~~the~~ maggot powder as a healthy food, can improve the ability of animals and humans to resists~~ing~~ harmful radiation and immune function effects.~~whether for animals or human body.~~ For ~~the~~ patients under treatment ~~of~~ using radiation or chemical therapies, the reduction of white cells and immune cells obviously slows down~~,~~ and ~~the~~ hair lost is apparently ~~decreasing~~decreased. The ingredient in maggot bodies that provides these functions is not certain, but there is a significant clinical effect ~~It is not sure what is the effective ingredient for these functions in maggot body, but there is a quite important clinical signification~~ for humans living in ~~the~~ space or on ~~the~~ earth.~~.~~ ~~The c~~Crops or animal internal organs could serve as~~be~~ feedstuff for rearing maggots on ~~the~~ earth or in ~~the~~ space, some herbal medicines and other ingredients with special function can be added in those feedstuff, or into maggot (pupa) powder for increased~~ing~~ effect. ~~It~~These can also be taken by the people who ~~have to touch~~are exposed to ~~with the~~ radiation or live in locations that are ~~in the place where is~~ polluted by radiation. Furthermore, ~~the~~ animals that feed~~ing~~ ~~by the~~on maggots, their meat and eggs can experience ~~have the~~ similar benefits~~function too~~. The daily dose for adults is 0.3~1.0 gram of pure maggot (pupa) powder.

Maggots can also be used as carriers for ~~some~~ special ingredients by feeding the maggots with relevant ingredients that humans need, such as vitamins, minerals, electrolytes and antibiotic etc. With this approach, ~~, so~~ the ~~rearing~~ animals reared on the maggots will serve~~be the~~as carriers for these relevant ingredients ~~too~~ by virtue of being feed~~ing~~ ~~with~~ on the~~o~~se maggots.

Researchers have ~~Russia and Korea has~~ exploited maggot carriers, for example, it has been demonstrated that maggots can contain enough antibiotics and trace

elements by rearing maggot with relevant ingredient~~[20]~~.

Merits of rearing maggots ~~in~~ on long term missions

The full rRecycleing ~~fully~~ of the wastes of human/animals and inedible crops in space is possible by rearing maggots which will be nourishing feedstuff for feeding animals, the animals and crops will be human food. This provides~~, it would achieve~~ a regenerative closed-loop food ~~regenerative~~ system ~~with close loops~~ in space.

2. Maggots ~~is~~ are an ideal food source ~~for~~ that ~~offering~~ offers many ~~kinds~~ types of nutrition such as rich protein, fatty acid, amino acids, vitamins, minerals, electrolytes and many unknown nutrients. Combined with the animals fed by maggots and crops, they can meet ~~the~~ most nutritional needs ~~of nutrition~~ for humans ~~in~~on ~~long~~ long-term space missions.

3~~,—~~. ~~With the storage technology of f~~Frozen fly eggs and animal eggs, oosperm and placenta, ~~they~~ can be frozen in liquid nitrogen for cryopreservation~~, could~~ to provide a~~ achieve~~ safe and sufficient food source and food ingredient storage arrangement for ~~in~~ long term missions.

4~~,—~~. Maggots and feeding animals all have strong reproduction abilit~~y~~ies, short life cycles and high growth speeds~~ of growth.~~. ~~It~~ Maggots are~~is~~ easy to rear continuously day and night ~~in~~ at high ~~density~~ densities to achieve ~~the~~ efficient and self-sufficient food production.

5~~,—~~. Maggots seldom get diseases. Rearing maggots and processing ~~of the~~ maggot powder are ~~all pathogens~~ pathogen-free and ~~chemicals~~ chemical-free activities. Using ~~it~~ maggots to feed animals for human foods is safe, and does not produce harmful substances ~~to~~ which could pollute the environment.

6~~,—~~. Technologies for rRearing maggots and animals are ~~all~~ well developed ~~technology which~~and can be easily transferred to space applications with ~~less~~ minimal research investment and time. To rear ~~them~~ maggots one only needs simple production equipment, operation, and techniques. The food production, processing and storage activities are all performed with little space, so that the cost of food production, processing, storage and waste recycling ~~could~~ can be minimized.

~~**013 What is Claimed is:**~~

~~1, Rearing Fly Larvae (maggot) and fly pupa in space as space food sources for animals and human~~

~~2. Rearing maggot in space as defined in claim 1, the human / animals waste (manure) and inedible crop plants in space be fully recycled to regenerate nourishing maggot biomass for. animal feedstuff~~

~~3, Rearing maggot as defined in claim 1, maggot can be carrier of some special ingredients by feeding maggot with relevant ingredients that crew need, such as vitamins, minerals, electrolytes and antibiotic etc., so the rearing animals will be the carrier for these relevant ingredients too by feeding with those maggot, the crew will get these relevant ingredients from these animal food.~~

~~4, Rearing maggot as space food source for animal as defined in claim 1, the enough fly eggs, animal eggs,~~

~~oosperm and placenta be all brought from earth, they were frozen in liquid nitrogen as the food source, and can be warmed and hatched for rearing in space, thus achieve safe and sufficient food source and ingredient storage in long term mission。 The animals could be reproduced by themselves in the space too. The fly rearing and reproduction could be a standby way for sudden case of fly eggs lost in long term mission.~~

~~5, Rearing maggot in space as defined in claim 1, when rearing maggot 3~3.5 days (or rearing after 4 days to become pupa),the living maggot (or pupa) could be feedstuff for rearing animals directly, or processing to be maggot powder (or pupa powder) for frozen storage as animals feedstuff.~~

~~6, Rearing maggot in space as defined in claim 1,the maggot will be feedstuff for poultry, aquatic, amphibian, and livestock, these animal bodies and their eggs will be the nourishing food for human in space.~~

~~7, Rearing maggot in space as defined in claim 1, the residues after rearing maggot is odorless and still rich of nutrients, it can be high grade fertilizer for crop plants, the~~ $\cancel{CO_2}$ ~~from maggot rearing, could supply to crop plants for growth requirement~~

~~8, Rearing maggot as defined in claim 1, for those food crisis in space or on the earth, such as disaster in polar adventure, on the sea or in war, rearing maggot with self-manure could be a way of self-sufficient food production for life saving.~~

~~9, Rearing maggot and fly pupa as defined in claim 1, the maggot powder, pupa powder and the rearing animals feeding by maggot and pupa, can be manufactured as healthy food for resisting radiation and improving immune ability, not only for human in space, also for human on the earth.. The crop or animal internal organs could be feedstuff for rearing maggot on the earth, some herbal medicine and other ingredients with special function can be added in those feedstuff, or in maggot (pupa) powder for increasing effect. The daily dose for adult is 0.3~1.0 gram of pure maggot (pupa) powder.~~

~~014~~ Abstract of the Disclosure

In ~~the~~ space, ~~the~~ wastes from humans, animals, and crops can be fully recycled by rearing maggots which will be nourishing feedstuff for feeding animals. These animals and their eggs combined~~s~~ with ~~the~~ crop plants ~~that NASA developed~~ will be varied food for humans in space. ~~The~~ Wwater and nutrition left ~~leaving~~ in the residues remaining after rearing the maggots can be recycled and used to fertilized ~~by the~~ crop plants ~~again~~. Rearing maggots, ~~and~~ animals, and ~~combined with~~ crop plants provides ~~could achieve~~ a self-sufficient food regenerative system ~~from most wastes~~ that ~~to~~ enables humans to live and work in space on long term missions -independent of ~~earth-provided~~ food from earth. ~~in long term mission~~.